A PRELIMINARY MODEL OF SUMMER PATCH

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In the early 1980's, Smiley and Fowler (1984) determined that *Phialophora graminicola* (Deacon) Walker and *Leptosphaeria korrae* Walker and Smith were the two principal causal agents of Fusarium blight or *Fusarium* blight syndrome (Smiley 1983). Summer patch is the newly accepted common name for the component of *Fusarium* blight syndrome caused by *P. graminicola* (Smiley 1984).

The initial symptoms of summer patch are chlorotic yellowing of turf in patches that average 6 inches to 12 inches in diameter, but can range from 3 inches to 3 feet (Vargas 1985). As the disease progresses, the patches enlarge, sometimes leaving a tuft of apparently unaffected, healthy turf in the center. There is evidence that the patches can coalesce into very large areas of damaged turf, and no longer resemble patch diseases (Smiley and Fowler 1985a).

Summer patch was first noted in Michigan by Vargas (1984, 1985) on annual bluegrass, *Poa annua* L. The disease was severe throughout the midwest in 1983 and 1984, particularly on annual bluegrass fairways on golf courses. Turf loss even occurred on golf courses where superintendents were using good fungicide programs for suppression of diseases such as anthracnose, dollar spot, and brown patch (Vargas 1985).

Currently, most information on the development and potential severity of summer patch is related to the environmental conditions encompassing *Poa pratensis* in New York. In general, Smiley and Fowler (1985b, c) have found that summer patch occurs first on closely mowed turf in July and August, during hot sunny days, directly after a period of excessive rainfall.

In Michigan, summer patch on annual bluegrass also appears to occur after a period of summer-like stress. However, little quantitative information is available on specific environmental or edaphic factors that lead to summer patch outbreaks on annual bluegrass. The need for information on the biology and management of summer patch has initiated a research project on the development of a mathematical model. This model will predict when summer patch outbreaks will occur and how severe they will be. The model will be available in a microprocessor for access and use on the golf course.

There are several benefits to a model that predicts the occurrence of a turfgrass disease. First, it provides an early warning system for golf course superintendents. Each day, the model monitors the weather and environmental conditions and calculates the probability that the disease will occur. Thus, superintendents are alerted to the disease problem before it occurs. Superintendents with large enough budgets to treat diseases with fungicides can use the model to more precisely time the fungicide applications. Superindentdents with smaller budgets benefit from the model even if they do not normally apply pesticides for disease prevention or suppression. By using the model, the superintendent can alert his greens committee, board or members and mapped the first patch in the fairway. Two days later we saw two more patches and by the 21st of August we counted 179 patches for an average of about 6 patches per 6 ft by 9-ft plot. The patches ranged in size from 3 to 17 inches in diameter with most patches only 5 to 8 inches in diameter.

Figure 1 shows the total number of patches on the fairway throughout August and September. Notice that the number of patches declined toward the end of August and by the first of September the patches had filled in and the symptoms were no longer visible again and remained so until the end of September.

Graphs of three environmental variables before and during the summer patch outbreaks are shown in Figures 2, 3, and 4. These graphs reveal some interesting and potentially important relationships in the epidemiology of summer patch.

In Figure 2 the average daily soil temperature on all 33 fairway plots is plotted in conjunction with the number of patches. There was a slight warming trend just before the disease symptoms became evident. Note that these average temperatures are much lower than the constant 29 C (84 F) temperatures used by Smiley and Craven Fowler (1985c) to induce summer patch symptoms on potted Kentucky bluegrass plants. However, the soil temperatures on our plots did exceed 80 F for a short time span nearly every afternoon. AT this time we can only conjecture that an accumulation of temperature units can eventually render the turfgrass susceptible. Based on Smiley and Fowler's work, we also assume that the quicker that soil heat units accumulate then the earlier that symptoms of summer patch will become evident.

Reduction in the prevalence of the patches during the first outbreak followed a reduction in average soil temperature to 68 to 70 F. As average soil temperatures increased to 72 F, 74 F and 78 F, we observed subsequent increases in the prevalence of the disease. The number of patches did not decline until nearly one week after average soil temperature had decreased to 62 F.

Figure 3 shows the relation between the total number of patches and the soil moisture potential measured each day in the later afternoon and averaged over all 33 fairway plots. The soil moisture potential remained at or above field capacity (-100 mbars) for the nine days prior to the first incidence of the disease and for the entire 14 days prior to outbreak when 179 patches were found. This relationship coincides with Smiley and Fowler's (1985c) findings that summer patch outbreaks followed periods of excessive rainfall.

At the peak of the first outbreak soil moisture potential decreased well below field capacity showing that the fairway received little or no water from irrigation or rainfall for several consecutive days. The soil moisture potential increased to a level above field capacity for 8 of the next 9 days. Three days prior to the initiation of the second outbreak the turf remained dry with the soil moisture potential dropping to nearly -300 mbars. On the first day of the second outbreak the soil became wet again and the soil moisture remained above field capacity for the next 10 days. During this period of high moisture , the prevalence of the disease increased. The soil moisture decreased again at the peak of the outbreak with no irrigation or rain for four consecutive days. As the number of patches stabilized and just about an impending outbreak. With the early warning from the model, the committee, Board or members know that the superintendent is aware of the outbreak even if no treatment is applied.

Development of the model also provides valuable information about cultural management of turfgrass diseases. For example, if our research shows that soil nutrient availability or moisture potential is related to the occurrence of the disease, then changes in the fertilizer or irrigation components of the management program could be employed to reduce the incidence or prevalence of the disease.

Methods and Materials

In the summer of 1985, research plots were established on the fifteenth fairway at Walnut Hills Country Club in East Lansing, Michigan. Twenty-seven 6-ft x 9-ft plots were located in a portion of the fairway where summer patch symptoms had been consistently observed over the four previous years. Six other 6-ft x 9-ft plots were located in nearby portions of the same fairway where summer patch symptoms had been less severe.

A microprocessor and a hygrothermograph were placed 12 ft from the fairway and within 80 ft of the edge of the furthest plots. The microprocessor continuously measured ambient and soil temperature and stored daily averages of soil temperature. The hygrothermograph continuously measured ambient and soil temperature and stored daily averages of soil temperature. The hygrothermograph continuously recorded ambient temperature and relative humidity at ground level.

Within each plot, soil temperature, soil moisture potential, and oxygen diffusion rates were measured at least once each day and often twice. A tranducer was used to electronically measure soil moisture potential at the soil-root interface. Soil temperature was measured with a tele-thermometer and oxygen diffusion rates were determined with an electronic ratemeter and platinum probes--1, 1.5, and 2 in. below the ground surface. Measurements were taken at sunrise and/or late in the afternoon to obtain information on minimum and maximum environmental conditions.

Summer patch symptoms were monitored on each visit to the fairway. Data on the number, size, and location of the patches were recorded on a grid map for each plot. The fungus was isolated by gently removing runner hyphae from the turfgrass roots and placing them on artificial media. Confirmation of the presence of the causal organism, Phialophora graminicola, was determined by symptomatology in the field, presence of runner hyphae and hyphopodia on the roots, and characteristics in culture including color, growth rate, hyphal branching and back-curling and presence of phialides with collarettes and phialospores.

Preliminary Results

Summer patch outbreaks were less severe in 1985 than in the preceding two years throughout Michigan. On our research plots at Walnut Hills Country Club in East Lansing, no patch symptoms were observed until mid-August. After several days of heavy to moderate rainfall, we noticed a mild chlorosis of the turfgrass similar to the symptoms of anthracnose. On August 16, we observed before the end of the second outbreak, the soil appeared to be watered every other day.

Oxygen diffusion rate (i.w., the rate of oxygen supply through the soil to the roots) is inversely related to soil moisture potential. In other words the higher the soil moisture potential, the lower the oxygen diffusion rate. In Figure 4, we see that the oxygen diffusion rate was low prior to the first incidence of the disease, increased as the outbreak peaked, and increased again just prior to the initiation of the second outbreak.

Conclusions

No single or isolated factor is responsible for inducing an outbreak of a disease such as summer patch. One factor may have a greater influence on disease development than other factors but the pathogen and its host respond to a variety of environmental stimuli. For example, Smiley and Fowler's work and our own observations of summer patch in the midwest indicate that summer patch occurs in the later summer when temperatures are high. We assume that the incidence of the disease is related to the warmer conditions. But we also know that the end of the summer brings about poorer soil moisture conditions, inadequate oxygen diffusion rates, and a general accumulation of saprophytic and parasitic soil organisms. Although we may assume that heat is a prerequisite for the initiation of the disease, it is plausible that the disease may occur during milder summers when other factors either increase the susceptibility of the turfgrass or the virulence of the pathogen. The summer of 1985 is a good example of this situation. The task of the modeler is to mathematically determine the probability of disease under a given set of interwoven factors that are continuously changing over time.

Our preliminary results indicate that summer patch outbreaks may occur on fairways where the soil temperatures average above 70 F and soil moisture remains excessively high (greater than -50 mbars) for several consecutive days or are allowed to dry for several consecutive days. This makes sense biologically because the pathogen grows better at higher temperatures and higher moisture levels, while the host responds poorly to high temperatures and drought. We continue to recommend that Poa annua fairways be watered daily when summer air temperatures exceed 80 F. However, these waterings should be light and are not necessary when it rains. Convesely, abrupt discontinuance of daily irrigation will result in less vigorous turfgrass which will be much more susceptible to summer patch outbreaks and less able to recuperate without chemical treatment.

Acknowledgements

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FIG. 1

TOTAL NUMBER OF PATCHES PER DAY

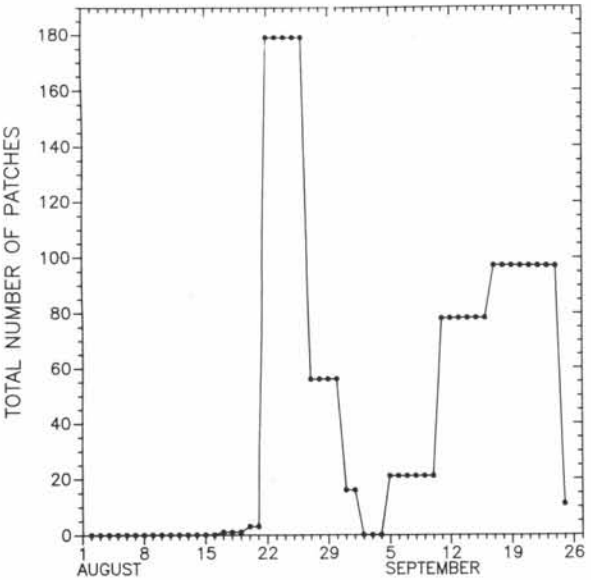
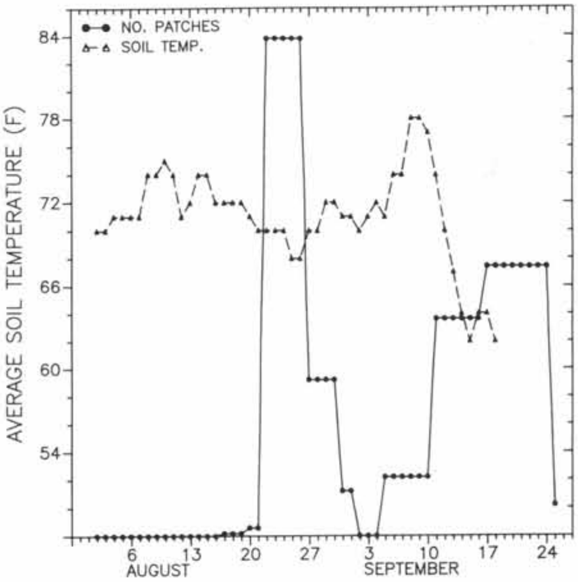


FIG. 2

AVERAGE SOIL TEMPERATURE PER DAY



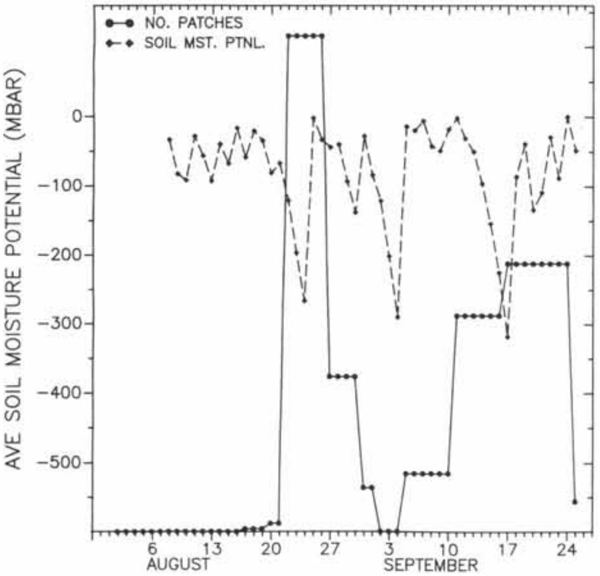


FIG. 3

AVERAGE SOIL MOISTURE POTENTIAL PER DAY

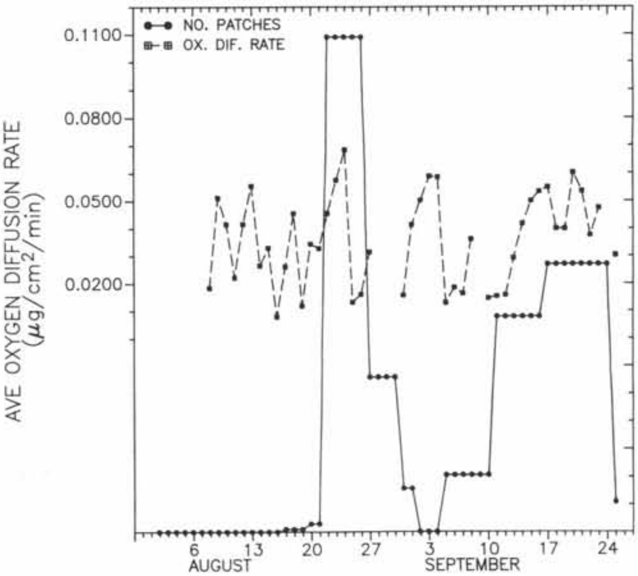


FIG. 4

AVERAGE OXYGEN DIFFUSION RATE PER DAY